



# Associating Hail Occurrence and Large Scale Environment for the Continental United States 1979-2012

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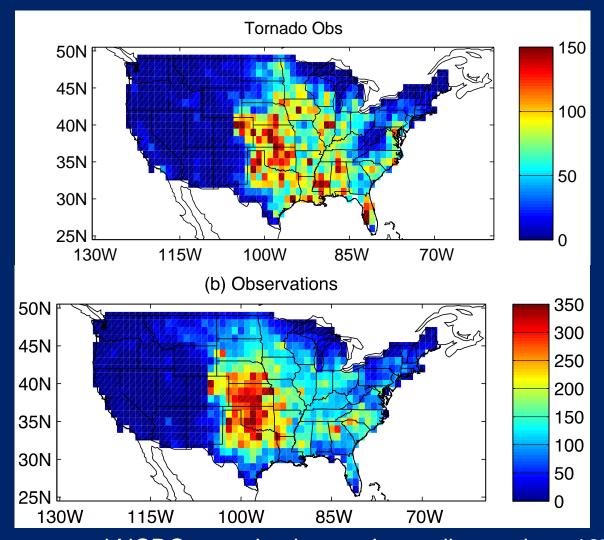
## The Challenge

 How do we extend forecasts of severe weather phenomena (e.g. hail, tornadoes) to periods outside a week?

## **Our Approach**

- Severe thunderstorm likelihood can be related to the environmental conditions that precede it – but linking this to the climate can be difficult.
- Choice between Dynamical or Statistical approaches.
- Can we define a statistical relationship that describes the occurrence of hail and is it different from that for tornadoes on a monthly basis?
- How does this relationship 'index' compare to climatology and interannual variability?

## Tornado and Hail Observational Climatologies Don't Look the Same



a) Mean annual NCDC tornado observations, all tornadoes 1979-2012.
b) Mean annual NCDC observed hail events for hail between one and two inches 1979-

2012.

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## **Apply a Poisson Regression**

- Use parameters than can be observed/modeled to develop a relationship.
- Assume a relationship of Index = exp(constants x parameters)
- 20 potential parameters:

**Thermodynamic:** (CAPE, CIN, Convective Precip., Lifted Condensation Level, Surface Theta-E, Surface to Freezing level relative humidity)

Kinematic: (Bulk Layer Shears, SRH)

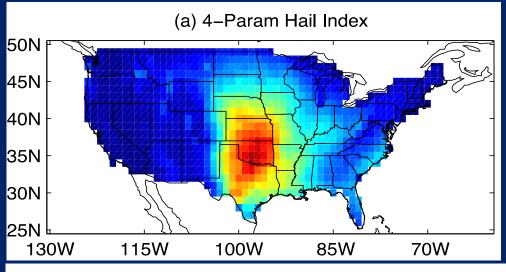
**Simple:** (Qmean, SoilM01, Temperature at 500mb)

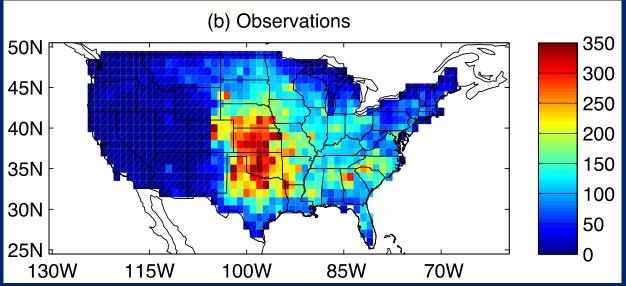
- Estimate constants using Poisson Regression from observed climatology of hail for the entire U.S. – avoids issues with changing technology and reporting.
- Data: Monthly mean NARR parameters on 1°x1° grid,

  NCDC/SPC hail between 1 and 2 inches 1979-2012 International Research Institute for Climate and Society

### **A New Hail Index**

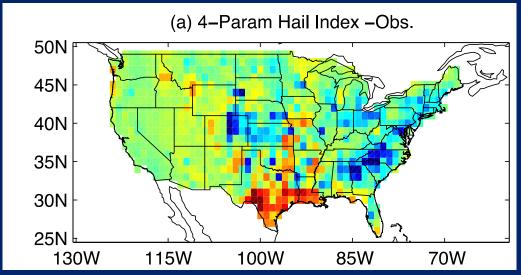
'Best'
Deviance/RMSE
4-param Index
cPrcp, SRH,
MLCAPE, Q<sub>mean</sub>

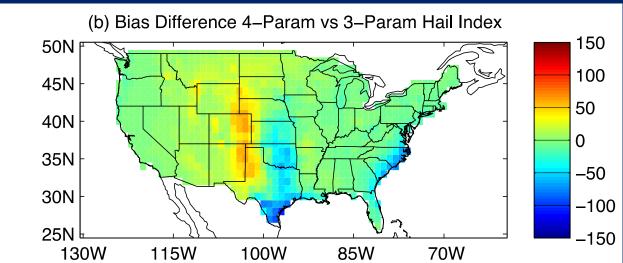




- a) Mean annual 4-parameter Hail index for hail between one and two inches 1979-2012.
- b) Mean annual observed hail events for hail between one and two inchesal 1972 h Institute for Climate and Society
  2012.

#### **Parameter Biases**





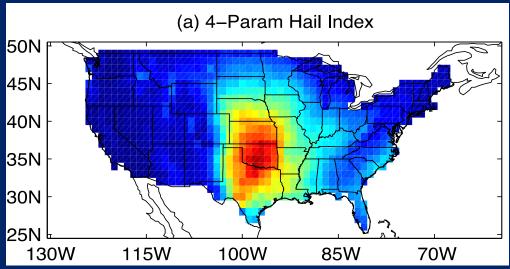
- a) Difference between 4-parameter Hail Index and Observations.
- b) Difference between the 3 and 4 parameter hail index showing the influence of the Q<sub>mean</sub> parameter.

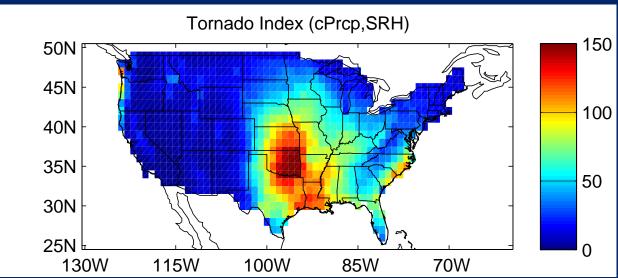
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## **Comparison to Tornado Index**

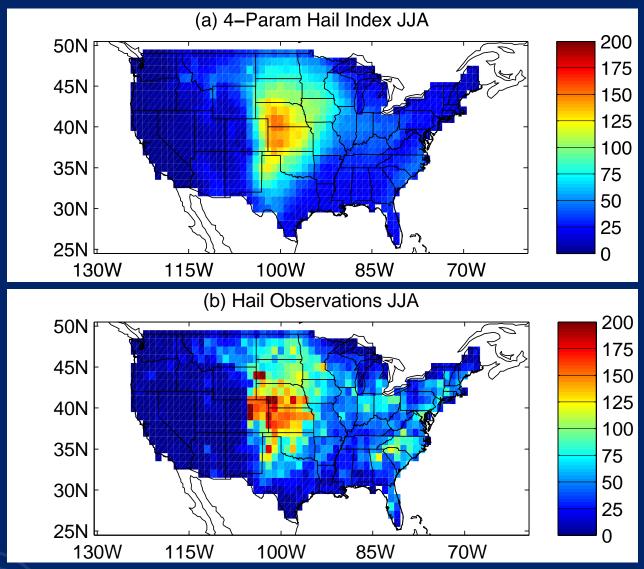
'Best'
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cPrcp, SRH,
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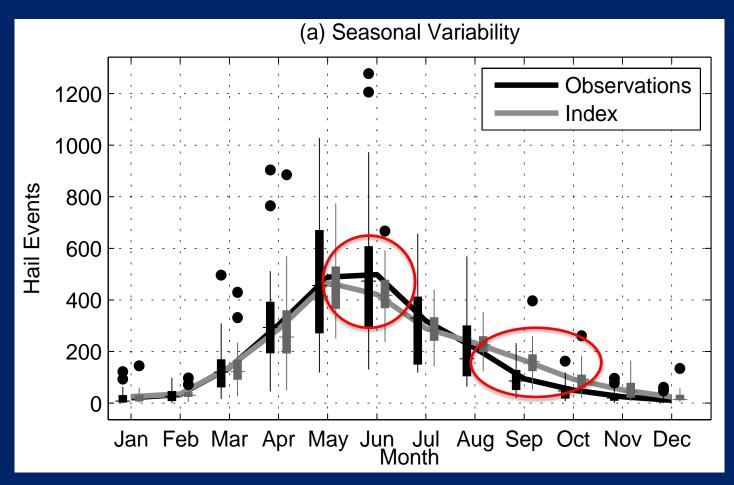
- a) Mean annual 4-parameter Hail index for hail between one and two inches 1979-2012.
- b) Mean annual 2-parameter Tornado index for all tornadoes F0+ 1970 at 2018 Search Institute For Climate and Society

## **Seasonal Performance - Summer**



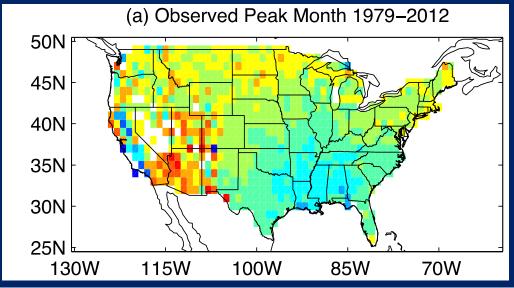
- a) Mean Hail Index JJA (1979-2012)
- b) Hail Observations JJA (1979-2012)

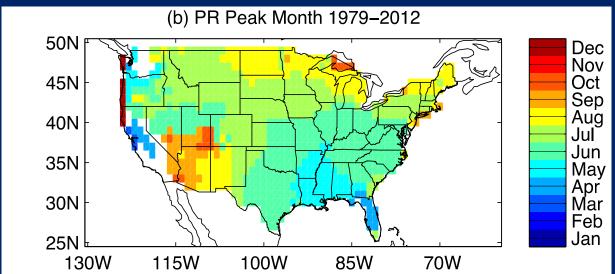
## **Seasonal Variability**



Seasonal variability of the hail index as compared to observations. Lines are mean index (grey) and obs. (black) seasonal cycle, whiskers reflect 2.7sigma (99.3%). Dots show outlying years.

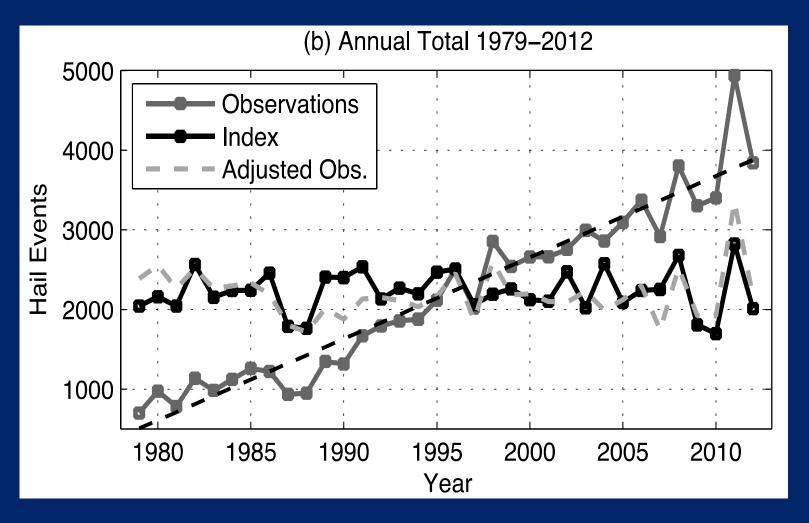
## **Spatial Seasonality**





- a) Mean observed peak month of observed hail events 1979-2012.
- b) Mean observed peak month of 4-parameter Hail index 1979-2012.

## **Annual CONUS Total Variability**



Variability in annual total of hail reports as compared to the index for the period 1979-2012. The adjusted observations have been linearly detrended.

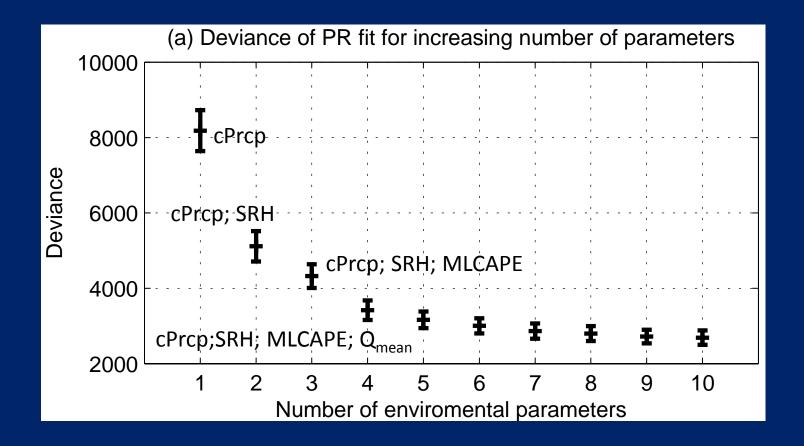
# **Summary**

- A new monthly hail index has been developed using Poisson regression to relate large-scale environment to the occurrence of hail between one and two inches, different to the index for tornadoes.
- The index produces a spatial distribution that while sensitive to the chosen dataset (due to the parameters), gives a better representation than existing indices for all severe weather.
- While monthly variability is less, the hail index gives a more spatially consistent depiction of seasonal variability and is not influenced by the trend seen in observations.

#### **Caveats**

- This is a good model, not 'the' model.
- A monthly index is somewhat removed from the highly diurnal structure of some variables critical to the development of severe hail (or tornadoes).

### **Allow the Data to Select: Deviance Minimization**



Fitting Poisson Regression to the monthly climatological observations for an increasing number of environmental parameters.